Embedded Training in a Ground Soldier System

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ABSTRACT

The historical debate, issues, and challenges surrounding embedded training, including a virtual simulation component, in a ground Soldier system are discussed. First, the history and interpretations of the embedded training concept are outlined. Second, the evolution of ground Soldier systems, the tasks performed with these systems, and the requirement for embedded training cited in system requirement documents are presented. The two systems described are the Land Warrior and Future Force Warrior. The challenges faced in incorporating embedded training in such systems and the potential role of embedded training are then addressed. In particular, the paper examines which tasks merit incorporating an embedded training component within these systems, as well as lessons learned regarding virtual simulations with these systems.

Keywords: Embedded training, ground Soldier systems, embedded exercises, Land Warrior, Future Force Warrior, training strategy, virtual simulation

1.0 HISTORY OF EMBEDDED TRAINING

In 1987, the Vice Chief of Staff, Army, and the Undersecretary of the Army issued a policy statement on embedded training (ET) (see Finley, Alderman, Peckham, & Strasel (1988). The policy required the Army to consider ET: "*An embedded training capability will be thoroughly evaluated and considered as the preferred alternative among other approaches to the incorporation of training sub-systems in the development and follow on Product Improvement Programs of all Army materiel system*" (p. 21). The rationale for ET was that "*Soldiers and units that deploy to combat with equipment that contain an embedded training capability will possess the tools necessary to sustain proficiency in conjunction with combat operations. Further, peacetime constraints on individual and collective training caused by time, space and resource shortfall are expected to continue"* (p. 21).

1.1 Definitions of ET

What is embedded training? Initial definitions were consistent, but over time, the concept expanded. In the 1987 Army policy guidance, ET was defined as "*training that is provided by capabilities designed to be built into or added onto operational systems to enhance and maintain the skill proficiency necessary to operate and maintain that equipment end item*" (Finley et al. 1988, p. 21). The definition was repeated in TRADOC Regulation 350-70 (TRADOC, 2007). It limited training to the operational system itself, emphasized individual operator and maintainer skills, and focused on enhancing and sustaining skill over providing initial training.

The 1987 policy statement also stated that ET should not adversely impact the system's operational capabilities, should be identified early to be included in prototype designs, and could train individual

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through collective tasks. That ET should not impact the system's operational capabilities impacted discussions about the scope and feasibility of ET with Soldier systems.

The 1987 definition lacked specificity. An operational definition was proposed in a series of ET reports in 1988 (see Finley, et al., 1988). The definition was expanded in Strasel, Dyer, Roth, Alderman, and Finley (1988), and repeated in later documents (TRADOC Pam 350-3, 2003; Witmer & Knerr, 1966). In Strasel et al. (1988), an ET system was "*a computer-based system, either integral to or adjunct to the prime system, which, when activated, interrupts or overlays the system's normal operational mode to enter a training and assessment mode*" (p. 6). ET is enabled on ground Soldier systems as they incorporate a computer and an operational display.

1.1.1 Implications of the ET definition

Major training capabilities associated with the definition included performance measurement, feedback, and record keeping and management of performance results (Strasel et al., 1988). Other essentials of a fully functioning ET system were cited. The ET system would have to generate and feed target or other signals to the system's displays and indicators. The input data must be realistic so Soldiers can perceive and react as if the system were in its operational mode. The ET mode therefore stimulates the prime system. One form of stimulation could be considered virtual. The ET system enables Soldiers to execute tasks as they would operationally, but with stimulated input. Additionally, the ET system would "score" Soldiers and provide performance feedback.

With ground Soldier systems, the ET stimulation enables the Soldier to perform tasks with the prime system's controls and displays, but it is training software in conjunction with the stimulation that triggers Soldier behaviors and produces the training. The software stimulating the system is typically the responsibility of software engineers. However, ET, by definition, must also include a training component, a capability typically designed by individuals with expertise in learning, measurement, and instructional design who must understand what will be effective with the Soldiers. A team of individuals is required to build a successful ET capability.

It is also important to establish boundaries for the ET concept. The definition excludes non-system tasks, simply embedding task information (i.e., a "book in a box") or memory aids, and performance support measures that "guide" individuals through execution of system tasks (e.g., a help system in a computer software package that can be consulted for information but not performance feedback). Training instead involves Soldiers performing system-related tasks and receiving performance feedback.

1.1.2 ET role in a training strategy

ET is only one component in a total system training program. This point was stressed in the early ET reports. Most likely ET is a part-task trainer, since critical conditions which trigger behaviors often cannot be replicated and/or some tasks are best trained under other conditions. Although the emphasis was on sustaining individual skills, it was acknowledged that ET could be used for initial skill acquisition and for collective training. The recommendation was to determine the exact nature and scope of ET on a case-by-case basis.

In addition, ET decisions should be iterative, as the information on the appropriateness, feasibility, and cost-effectiveness of ET increases throughout the acquisition process (Strasel et al., 1988). This point is relevant to ground Soldier systems as various prototypes of the system that will eventually be fielded, called the Ground Soldier System (GSS), have been built. These prototypes include Land Warrior (LW) and Future Force Warrior (FFW). The Army has had extensive experience with the LW system; it has been a test bed for the GSS; deployed units have used it. The FFW was the centerpiece of an Advanced

Technology Demonstration (2003-2007) that examined technologies for future ground Soldier systems. Consequently, the primary tasks that Soldiers must perform on these systems are well known as are system computer capabilities, controls, and displays.

1.2 Types of ET

Witmer and Knerr (1996) specified three types of ET: fully embedded, appended or strap-on, and umbilical. They differed in the extent to which the ET system is fully contained in the prime system. Ground Soldier systems are constrained by size, weight, and power (SWAP), which impact the feasible types of ET.

With the fully embedded concept, all training features, except for perhaps easily installed training software, are fully contained in the prime system. Soldiers go to war with the ET system. ET meets the reliability, availability and maintainability requirements of the prime system. This “go to war” feature is critical when considering Solder systems, given the system’s SWAP constraints.

Appended ET “can be installed on or attached to the prime system when needed and removed when not needed” (Witmer & Knerr, 1996, p. 11). To be functional, it would likely require some permanent physical components (brackets, sensors) or connection to a spare universal serial bus. This mode could be used in assembly areas or in forward operating bases, and perhaps as a “go to war” capability.

Umbilical ET is like appended, but involves physical connection(s) to external components, such as a computer, communications systems, or an instructor/operator console. The ET component allows umbilical forms to interface with system components. Witmer and Knerr (1996) indicated that umbilical ET may interconnect systems, as in simulated networking for force-on-force training. However umbilical ET “is not a go-to-war training system. It cannot train ‘on the move’.” (p. 11).

2.0 PROTOTYPES OF THE GROUND SOLDIER SYSTEM

2.1 Land Warrior

The LW system has a wearable computer with special software, a global positioning system which tracks the location of individuals, a helmet-mounted display, and a radio, each linked to a network. The LW concept and system have evolved. Since LW’s start in 1993, requirement documents have been updated and different LW systems have been built as technology and user requirements have changed. The LW operational requirements are similar to those for the GSS (Training and Doctrine Command [TRADOC], 2006, 2009), although the 2006 GSS requirement document added embedded training.

The LW helmet-mounted display enables the Soldier/leader to see maps, graphic control symbols, messages, his own position and the position of others, digital images, and mission orders. Users can create, send, and receive messages, orders, and graphics. Although orders and graphic overlays can be created on individual systems, these mission planning documents are typically created at company or battalion and then downloaded to leaders. Early versions of LW integrated a weapon subsystem which allowed reduced exposure firing. Soldiers could fire their weapon via a projected image of a target from a weapon sight to their helmet-mounted display. The exact LW configuration, weight, and location and size of major components have changed with system evolution. See Copeland (2007) for a description of one version of the LW. Figure 1 shows two versions of LW.

***Figure 1*. Two versions of the LW system**

The picture on the right is a version of LW which included weapon optics that enabled reduced exposure firing. The other pictures are of a more current system. The leader on the left is manipulating the interface with his left (non-firing) hand on the Soldier Control Unit while observing changes in the interface with his helmet mounted display (non-firing eye).

The two features of the current LW system most well-known and praised by leaders participating in Operation Iraqi Freedom are situation awareness (SA) features (icons indicating leader location in real time) and tactical symbol marking capabilities. These two features interact, enabling critical situational awareness, clear communication of intent, and quick mission execution. See the Program Executive Office (PEO) Soldier web site (https://peo.soldier.army.mil/multimedia.asp) for videos entitled "Keep up the Fire" where leaders describe these capabilities. Currently, only fire team leaders and above have the system, although all Soldiers in a squad had earlier versions of LW.

Figure 2 shows the main display in one version of LW. In the center is the map, which can be a digital map or imagery. Also shown is the chevron depicting the user's location (the "graphic bearing indicator"), and circular icons indicating the location of other individuals. The bottom tool bar alerts the user to incoming messages (voice and digital), SA, and battery power. The top tool bar leads to a library of photographic/digital images (Image tab), to a drop-down menu of major functions from the Menu tab (messages, configure the system, orders, etc.), the grid of the user, and date/time group. Many functions under the Menu tab can be accessed via other tabs on the screen. The tool bar immediately below the top tool bar accesses map tools, operational graphic symbols, maps, etc. The side tool bar enables the leader to tailor map displays.

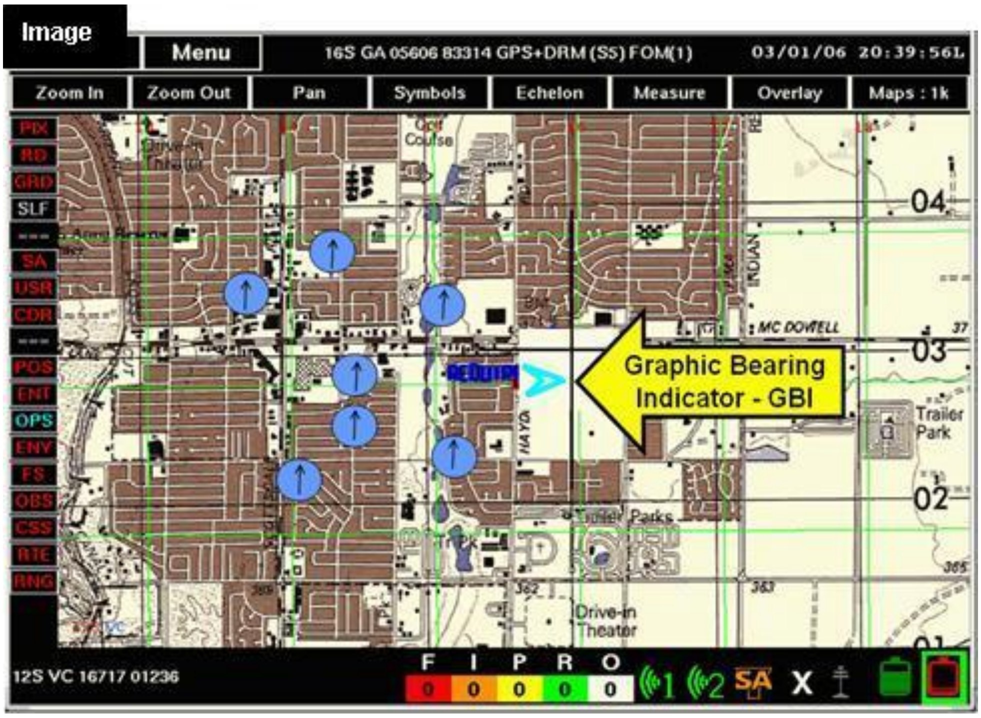


Figure 2. **Main screen in LW interface**

Some functions can be executed in more than way. For example, you can select a message by going through the Menu and also by clicking on the screen. A call for medic can also be sent with a Soldier Control Unit button.

2.2 Future Force Warrior

The FFW program was the U.S. Army's broad experimental effort examining a wide range of technologies for the ground Soldier. With FFW, the squad leader had a computer system similar in capability to the LW, although the software interface differed and leaders had varied displays including goggle-mounted. Some leaders had a fused sensor capability in their helmets. A unique technology was cooperative engagement allowing the grenadier to fire on unobserved targets. This non-line-of sight capability enabled a leader to designate a target for the grenadier using a multifunction laser. The leader transmitted the target location to the grenadier, whose sighting system calculated engagement elevation and azimuth to the target from the grenadier's position. The grenadier then oriented the weapon, checked for mask and overhead clearance, and engaged the target.

The FFW team leader's system was a hand-held personal digital assistant with fewer capabilities than the leader system. It had situation awareness features, plus basic map, graphic and message tools (see Figure 3).

***Figure 3*. FFW team leader system – PDA**

3.0 ET REQUIREMENT FOR THE GROUND SOLDIER SYSTEM

Embedded training was a key performance parameter (KPP) in the initial requirement document for the GSS (TRADOC, 2006). A KPP requirement is one that must be met by specified system milestones. The ET requirement for the Future Combat Systems (FCS) greatly influenced the GSS ET requirement.

The ET KPP requirement had multiple components. The "T" and "O" in the statement below refer to the threshold and objective phases of system development. The ET KPP was: "*The GSS must support 100% of the top-level ET tasks and over 70% of the second-level tasks (T), all ET tasks (O).*

… must provide a 'reach back' capability to retrieve additional training products not hosted by the Soldier system (O).

… must be compatible with current force-on-force tactical engagement simulation systems (T) and future embedded Tactical Engagement Simulation Systems (TESS) (O)

… must facilitate collaborative course of action analysis and wargaming mission rehearsal, and after action reviews (O)" (TRADOC, 2006, p. 11).

The rationale for the ET KPP stressed the importance of having a readily available training capability to sustain proficiency on complex tasks and perishable skills. The rationale also stressed embedded live, virtual and constructive training (L-V-C), consistent with FCS. The L-V-C requirement was not in the ET KPP per se, but was cited as a non-KPP ET requirement.

As the FFW program focused on integrating technologies into future systems, an ET architecture document (Hall et al., 2005) examined how to achieve the GSS ET requirements. All the GSS ET requirements were conceptualized as under the "ET umbrella," even though some did not correspond to the historical definition of ET. The next section discusses the relationship between the GSS ET requirements and the historical concept of ET which emerged from the FFW ET analysis.

3.1 ET requirements not involving simulation

Both the reach back and TESS capabilities cited in the ET KPP do not involve simulation. TESS is a live-fire capability that facilitates training of collective tasks. The long-term goals were to have a totally embedded TESS capability rather than a “strap on” version and to enable L-V-C training via the system’s network. The reach back capability would enable Soldiers, via the network, to access training materials in an external repository. However, this capability is not ET; no training is involved. A reach back capability was not developed during the FFW program. An embedded information capability in the form of memory joggers was developed. Memory joggers were single screen displays of essential, yet easily forgotten, information critical to small-unit leaders and Soldiers. Two memory joggers actually incorporated in the FFW systems are in Figure 4.

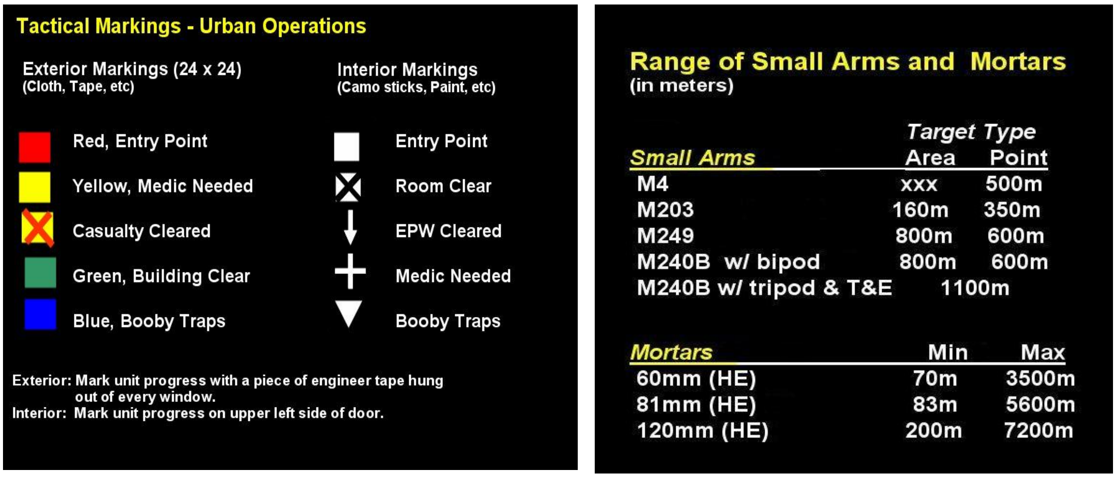


Figure 4. **Two memory joggers developed for the FFW leader system**

3.2 ET tasks

The first ET KPP statement relates to individual Soldier tasks and requires that ET tasks be identified and separated into higher and lower priority categories. The phrase “ET tasks” implies that only some Soldier tasks are appropriate for ET. This part of the KPP is consistent with the historical definition, in that in order to address ET tasks, the system would shift from an operational to a training mode with embedded training exercises stimulating system displays, requiring Soldier actions, and providing performance feedback. Many exercises would likely involve some form of virtual simulation.

Although no embedded training exercises were included in the actual FFW systems, examples of what could be done were developed. Figures 5 and 6 show a simple four-screen individual navigation planning exercise. A scoring scheme is also illustrated.

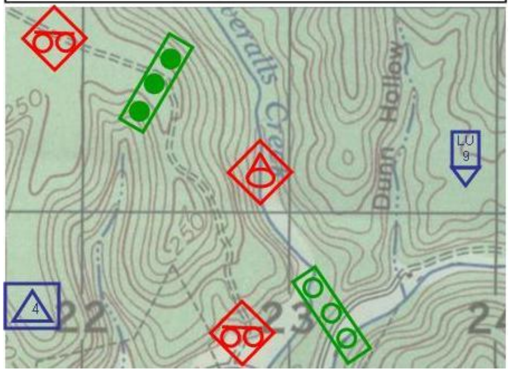
①

Insert task performance requirement on display.

System in training mode.
Show requirement situation via Soldier display.
Use system controls to activate the appropriate map symbols to insert required symbols.
Exercises would focus on cognitive skills as well as "knobology".

System stimulated with this input

"You currently occupy OP 4 with your buddy. You have been directed to move to LINKUP POINT 9. Avoid contact and injury. Plan and indicate your route using WAY POINTS. You will be scored on your performance."

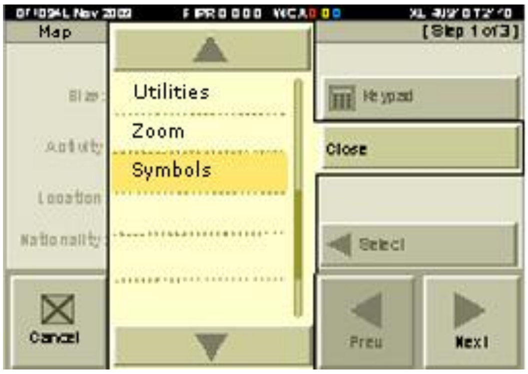


②

System in training mode.

Display permits Soldier to select the appropriate items from his display.

Soldier navigates buttons and menus to select desired map functions.



③

Should the Soldier make an error, a warning prompt lets him try again. {e.g., *Think Again!! You made a wrong selection.*}

Correct selection of menu items permits Soldier to proceed.
Upon selection of the correct button, the system will permit the Soldier to insert his navigation WAYPOINT(S) on his map, creating his navigation solution.

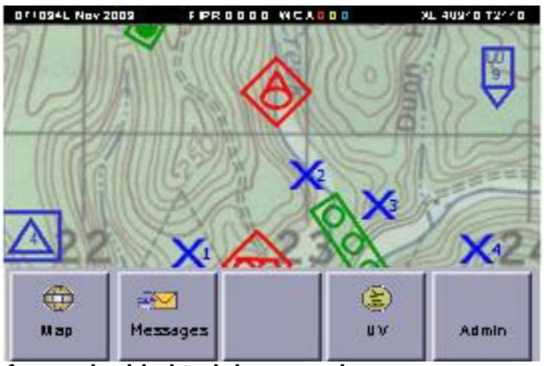


Figure 5. **First three steps in an example of an embedded training exercise**

④

Soldier receives feedback on such dimensions as:
Accurate menu navigation
Selection of symbols
Selection of point(s) or route segment(s) that place him at risk
Time to complete exercise

Feedback should include both assessment of system operation & conceptual /decision skills

Example Feedback Screen

Menu navigation:
☑ **No errors**
☒ ___ errors in menu navigation detected.
Description:
☑ **Correct symbol selected**
☒ Incorrect symbol selected.
Point/route selection:
☑ **Safe route selected.**
☒ Points or route segments in **BROWN** place movement at risk or require additional movement time/distance.
Time:
Beginner
☑ **Intermediate**
Expert

View Map

***Figure 6*. Fourth and last step in an example of an embedded training exercise.**

3.3 Leader planning

The last statement in the ET KPP refers to leader tasks and requires leaders to collaborate over the network for planning and mission rehearsal. It implies that mission data on individual systems would be retained to support after action reviews (AARs). This statement greatly expands the original concept of ET, and reflects both an operational and a training support requirement.

When the ET architecture analysis was conducted, the FCS program specified using the newest Army constructive simulation called One Semi-Automated Forces (OneSAF). OneSAF would enable mission planning and be the semi-automated force engine for virtual collective exercises. OneSAF was examined in the FFW ET architecture document as a means to conduct course of action analysis during military planning. In later research with OneSAF, James, Dyer and Wampler (2008) found that OneSAF was not user-friendly for platoon leaders or company commanders in a combat situation. In addition, the computer requirements for OneSAF far exceed those inherent in a Soldier system. Yet collaborative planning among leaders is possible by using the operational system's networked capability to share orders and overlays, without incorporating a training or simulation capability.

Lastly, a limited, umbilical AAR capability was explored in the FFW program. A computer received digital data on Soldier locations from each FFW system and then displayed them at mission's end for examination and review by leaders.

3.4 Virtual collective capabilities

The FFW ET architecture document also examined virtual training executed in a training facility and in a "stand-alone" mode. A virtual collective training capability was not executed during the FFW program. However, two concepts were presented in the ET architecture document.

One concept examined a fixed facility, such as the Soldier Visualization Stations at Ft. Benning, GA whereby Soldiers wearing a GSS ensemble "would step into" a virtual environment and execute collective tasks (i.e., operate the system as in a live-training environment). To simplify, this is similar to a TESS exercise in the field, except in a virtual world instead. This capability would also allow individuals in a virtual environment to connect with leaders training in a constructive environment and with units conducting live-training. However, it is possible that some GSS capabilities may not be exercised fully or realistically in this virtual environment.

The other concept was to enable Soldiers to be in a virtual world using a special heads-up display, without a fixed facility. This technology was explored in the Research Development and Engineering Command's Advanced Technology Objective for "Embedded Combined Arms Team Training and Mission Rehearsal." Two key components were a special heads-up display to present a virtual world to the Soldier and a very powerful wearable computer to generate virtual world displays through gaming engines and similar technologies. This effort did not incorporate an actual Soldier system.

3.5 Summary

The FFW architecture document showed there were only a few GSS ET requirements where virtual simulation was applicable. One of these was embedded exercises to train the top-level and second-level individual ET tasks. As part of the FFW program, a rationale to identify these ET task candidates was proposed. A revised version of the rationale is presented next.

4.0 DETERMINING THE ET TASKS FOR A GROUND SOLDIER SYSTEM

4.1 General Approaches for Selecting Candidate Tasks and Skills for ET

How do you decide which tasks and skills are appropriate for ET exercises and justify incorporation in the system design? Historically, the ET reports and documents posed questions focusing on helping decision-makers make policy and engineering decisions regarding whether and in what form to use ET (Strasel et al., 1988; Witmer & Knerr, 1996).

However, Strasel et al. (1988) did cite some general guidelines for selecting tasks. One approach focused on the stimulus characteristics of tasks to determine ET sustainment requirements: whether battlefield stimuli were needed for sustainment training, the complexity of system tasks and how often they are performed, the extent to which the Soldier must react to multiple controls and stimuli, and the need to track targets.

Another approach examined the criticality of tasks to mission success and perishability of component skills. Categories from most to least perishable were: integrated multiple skill performance, variable or contingency procedures, use of rules or concepts, invariant procedures, basic manipulative skills, and knowledge. According to Strasel et al. (1988), tasks requiring integrated multiple skill performance are always candidates for ET. On the other hand, tasks requiring basic manipulative skills or knowledge should be eliminated for sustainment ET, but could be included in ET for initial skill acquisition.

4.2 An Approach for Identifying Ground Soldier System ET Tasks

The proposed ET task rationale for identifying ET tasks per the GSS ET KPP was generated given knowledge of LW and FFW tasks. Typical tasks required by the LW and FFW systems, primarily LW, are listed below.

- Assemble the system
- Conduct start up and shut down procedures
- Configure the system (e.g., SA displays, navigation subsystem, alerts, message recipients)
- Manipulate the map (zoom, rotate, select maps) and use basic map functions (plot and edit symbols, plot a route, measure distance, determine azimuth)
- Use system controls (e.g., Soldier Control Unit [mouse, push to talk buttons], weapon-related controls)
- React to alerts
- Change map display filters or tailor details to depict relevant information (SA icons, overlays)
- Generate and send digital messages
- Use e-mail features
- Use voice communications capabilities (send/receive messages, establish/change talk groups)
- Capture, edit and send digital images to include overlays and photos
- Navigate with system
- Perform pre-operation checks; operator maintenance; trouble shoot system
- Conduct mission planning – higher level leaders or selected individuals: create/modify orders and overlays; create mission data package
- Execute weapon-related tasks (assumes integrated weapon subsystem such as daylight video sight, multi-function laser, thermal weapon sight, grenadier non-line-of sight system).

Two major phrases constituted the ET rationale. The first identified candidate ET tasks. The second selected the top ET tasks from among the candidate tasks. The rationale is a funnel approach, starting with all individual system tasks and then eliminating tasks. Questions in the first phase were based on psychological dimensions (retention, hard to learn/perform) and stimulus/task characteristics. Questions that identified the top ET tasks were based on military criteria: whether the task contributed to lethality or survivability, and to actions on the objective. For each question, possible decisions were:

- Eliminate as a candidate for ET – not train or sustain via ET
- Retain in the task pool for further consideration
- Select as task for ET or top ET

The proposed rationale is in Table 1. The questions are oriented toward using ET for sustainment, rather than for initial training of skills.

Table 1: ***Rationale for Identifying Ground Soldier System Tasks to be Sustained via ET***

	Question	Answer, Decision, and Rationale for Decision
	Phase IA. Identify ET Tasks (Eliminate tasks, none selected)	
1	Is this task done before the Soldier has turned on the system?	If "Yes," eliminate. System not on and there is no access to computer capability. If "No," retain.
2	Is this task done after the Soldier has shut down the system?	If "Yes," eliminate; no access to computer capability. If "No," retain.
3	To what extent is this task executed by all users?	If "limited number of users" then eliminate; not cost-effective. If "almost all users," retain.
4	Is this task done almost every time the Soldier uses the system <u>and</u> is it simple to perform?	If "Yes," eliminate; tasks are done repeatedly and are easy (e.g., log-on, some pre-op checks or default checks). If "No," retain.
5	Does the system provide sufficient cues so the task can be performed with little or no initial instructions?	If "Yes," eliminate; ET not needed for skill sustainment, or extensive training. If "No," retain.
	Phase IB. Identify ET Tasks (Select specific tasks)	
6	Is the task critical, but performed infrequently?	If "Yes," select as candidate for ET; will assist in sustaining skills. If "No," retain.
7a	Must the task be done relatively quickly <u>and</u> accurately in most situations?	If "Yes," go to Question 7b. If "No," retain; go to Question 8.
7b	If "Yes" is it difficult to perform quickly and accurately?	If "Yes," select as candidate for ET; will assist in training and sustaining skills. If "No," retain.
8	Do the skills that support this task decay rapidly without feedback or practice?	If "Yes," select as candidate for ET, will assist in training and sustaining skills. If "No," retain.
9	Does the task require extensive hands-on practice to maintain skill (e.g., eye-hand body coordination, physical dexterity)?	If "No," retain. If "Yes," select; Must be performed repeatedly, feedback needed.
10	Can the conditions under which this task is performed (body position, combat situation, day/night) be quite varied, and practice /experience with these different conditions is needed?	If "Yes," select. Training exercises can simulate different conditions. If "No," retain.
11	Are the steps necessary to perform this task likely to be confused with other tasks?	If "Yes," select; ET is a means of reducing interference among tasks. If "No" and also "No" to questions 8, 9, 10, and 11, eliminate. Distinct skill that is not confused with others and does not have other characteristics that justify ET.
	Phase IC. Identify ET Tasks (Re-examine all tasks in terms of a domain or cluster of similar tasks and memory jogger option)	
12	Considering all eliminated tasks, can any be grouped by domain, where the domain itself warrants ET?	If "No," go to question 13 If "Yes" select domain vs. individual task. .

	Question	Answer, Decision, and Rationale for Decision
13	Considering all selected tasks, can any be grouped by domain, where the domain itself warrants ET?	If "No," go to question 14 If "Yes," select domain vs. individual task.
14	Are there any tasks for which memory aids should be developed instead of exercises to maintain desired level of proficiency?	If "Yes," consider embedding the information as a memory aid.
15	Are there any remaining tasks that should be eliminated?	If "Yes," eliminate.
	Phase II. Identify Top-Level Tasks	**(From tasks selected in Phase I)**
T1	Does the task contribute to lethality?	If "No," go to Question T2. If "Yes," retain and go to question T3.
T2	Does the task contribute to survivability?	If "No," go to Question T3. If "Yes," retain and go to question T3.
T3	Does the task contribute to actions on the objective and/or execution of battle drills?	If "No," is not a Top-level ET task. If "Yes," is a Top-level ET task; contributes to battlefield lethality or survivability and is done when in contact with the enemy. Must be trained and sustained.

4.2.1 Application of the rationale

Although the rationale in Table 1 has not been validated, how it might be applied is illustrated with some LW tasks. Tasks such as assemble the system and conduct startup and shut down procedures would be eliminated by Question 1 as there is no computer capability. Tasks related to configure the system would be eliminated by Question 4. Map-related tasks such as zoom in/out and rotate can be executed with no to minimal instructions (Question 5), as the tabs for these functions are on the main display and how to access them is clear. They could be eliminated.

Consider the eight messages that can be generated and sent with LW: Call for medic (CFM), spot report, call for fire, free text, unexploded ordnance (UXO), tactical symbols, "send IED" (improvised explosive device), and "send SAF" (small arms fire). In order to make ET decisions for messages, it is necessary to define the scope of the tasks. Do the message tasks include the e-mail functions on the LW system? For purposes of discussion, it is assumed message tasks include e-mail functions and the start point is identifying who is to receive the message. Associated with each system is a set of default recipients tailored to the duty position of the individual and the type of message. Typically, leaders use the default setting. In other cases, leaders may elect to change these settings. This part of the task is done infrequently and might require refresher training (Question 8). Another point is that the user can access the message menu two ways, and neither means is immediately obvious from the main display.

The messages fall into three groups. The CFM, spot report, call for fire, free text, and UXO are common messages for leaders. There is a limited requirement to train leaders on their purpose and content. However, the tactical symbols are a new concept. Leaders must know when and how they can best be used, how to change their color, and how to remove them or modify them during a combat situation. In the planning phase, placement of the tactical symbols need not be done quickly, but during combat, leaders must execute changes quickly, perhaps under stress. During combat, if a leader is to move a symbol to a different location, he must relate what he sees and/or hears in his sector of responsibility to the displayed map and then place the symbol appropriately. The last two messages – "send IED" and "send SAF" – are quick ways of providing information on where an IED or enemy SAF occurred. It is a simple process; click on the appropriate location on the map and click on "send X." The locations of the IED and the SAF are immediately transmitted to others in the unit. As with tactical symbols, training needs to insure the leader is aware of the environmental cues regarding the location of the IED or SAF and can associate these to the map display so the markings are correct.

When considering each message independently, none may seem to warrant ET. However, when viewed as a "message domain" (Phase IIC), ET could be considered. Developing ET for a task domain also makes it easier to design training, to create exercises that motivate individuals, and to include exercises of increasing difficulty and complexity. If the training is of poor quality, embedded exercises will not be effective nor will they be used. Figures 5 and 6 correspond to an interactive multi-media training model. But other approaches could be considered. For example, one could display a "virtual" vignette on the helmet-mounted display or a linked computer monitor. At end of the vignette, questions could be posed that require specific Soldier actions with the system, or a replay with a pause capability could be implemented where Soldiers decide which actions to take with the system.

Although memory aids are not ET, they might be appropriate for some functions (Question 14). For example, an aid might be helpful in describing the three-letter abbreviations or symbols on tool bars. It is possible that when the rationale is validated with LW users, memory aids might be a better means of sustaining skills than exercises, and might be more acceptable to Soldiers.

4.2.2 ET in a training strategy

Although the rationale in Table 1 selects tasks for sustainment training, there is a strong argument for using embedded exercises for initial training. A recurring difficulty with ground Soldier system training is that the trainer cannot observe what the Soldier/leader is doing while interacting with the system display (Dyer, 2009). All the trainer can do is turn around the helmet-mounted display and look at the individual's screen after a task is completed. The trainer does not know how the task was completed or whether problems occurred. ET modules could be developed for this initial instruction. Since ET exercises must be scored and results stored in a data base, a trainer would be able to easily identify problems and provide remediation. If the primary purpose of ET was for this purpose, the questions in Phase IB of Table 1 should be modified to address initial training as well as sustainment. Use of ET for initial training would also help address train-up issues associated with personnel turbulence in units.

When considering ET in a comprehensive training strategy, the system must be available to the Soldier/leader. If the system is a sensitive item of equipment, then availability becomes an issue.

4.3 The Potential Role of Virtual Simulation for ET Collective Exercises

ET training exercises for individual skills can involve some aspect of virtual simulation. However, they are not the L-V-C force-on-force collective exercises that many envision with simulation. Challenges and limitations associated with virtual simulations for dismounted Soldiers are documented elsewhere. However, a few examples may help illustrate the issue. A significant concern is replicating a realistic environment for the small unit and the individual Soldier/leader. Many cues and signals used by a fire team as it sets to clear a room are tactile. The four-man stack uses touch, and hand and arm visual signals to provide status, announce the plan, and signal readiness for the blow of the door, entry hole, or grenade. Soldiers attend to what they hear to locate enemy forces or non-combatants in the target room. In open terrain, the subtle undulations of the ground or tree spacing looked for by the Soldier about to make the next rush are difficult to replicate. For small units, mission rehearsal is maneuver on the ground, or as some have said "If you're not sweating, you're not rehearsing." For the individual Soldier and the small unit, confidence comes from practicing on ground similar to the objective and rehearsing critical tasks over actual times and distances.

4.3.1 Challenges with ground Soldier systems

Understanding and acknowledging the human dimension is critical when considering a virtual environment for small-unit operations and Soldiers/leaders. What virtual training environment is acceptable and will be perceived as beneficial? These are not trivial questions. Historically ground Soldier systems have not necessarily been viewed by unit leaders as a battlefield asset (see the PEO Soldier web site [https://peo.soldier.army.mil /multimedia.asp]). Since Soldiers/leaders prefer live training, an even greater challenge is to develop a virtual training capability that is perceived as value added.

What features must the virtual world incorporate specifically for ground Soldier systems? Night scenarios, not day, should be the default condition as night operations are common with ground Soldier systems. Technology will probably eventually provide an image that realistically replicates what a Soldier/leader sees via night vision goggles as well as enhanced goggles that fuse image intensification and thermal imagery. However, the night simulation will be partial. For example, it will not replicate the personal uncertainty associated with night operations and the difficulties in quietly executing rapid unit movements and maneuver.

Environmental sounds and voice communications over the net are critical to small-unit operations with ground Soldier systems. Triggers for interacting with the Soldier display (when to check SA, change the display, pull up an image, send a message, locate an IED) are often auditory as well as visual. Directional sound capability in a virtual environment is necessary.

To enable the call for medic feature in the LW system, it is necessary to simulate injured Soldiers. Often in virtual environments the outcomes are dichotomous - killed or not killed. Injured Soldiers are not depicted.

Another question concerns how to leverage the combat benefits of ground Soldier systems in a virtual environment. Units equipped with LW have learned they can move faster, have better SA, can make more informed decisions, and can react faster to a threat with these systems. Can a virtual environment be used to show them what happens when they fail to use these assets? Can a virtual environment facilitate these skills?

Fully embedded virtual simulations for collective training are probably not possible with ground Soldier systems because of their limited computer power to support most simulations, and cannot address the challenges of simultaneously presenting the real world and the system display to the user. An appended capability or a fixed facility might be the engineering solution. However, with respect to an appended ET, the Army's experience with TESS indicates that logistical issues associated with strap-on training devices reduce the extent to which they are used.

4.3.2 Applications.

A significant contribution to small-unit proficiency may be derived from virtual environments in the refinement of some team and special skills proficiency training. The cooperative engagement capability in the FFW illustrates such specific skill training. During FFW training, the execution times for simulated cooperative engagements with the grenadier were slow. From target acquisition through approval to delivery, the total time was three minutes, sometimes longer. The required skills were precise manipulation of a software interface and of the sight and weapon. These were triggered by various stimuli: an incoming message, a system alert, or visual depiction in the sight subsystem. However, cooperative engagement had value: increased unit survivability, more enemy casualties, and disruption to the hostile force by a surprise engagement. With extensive practice, teams cut the engagement times to less than 15 seconds.

While practice was the key to improvement, it was also resource heavy. It required the entire team, squad leader, team leader, and the grenadier, as well as, the network, both digital and voice communications. These same and similar skill sets could be practiced and refined individually in a virtual environment without requiring an active network. Vignettes, tailored to duty position, could provide the needed stimulus, targets, maps, messages, and sight system graphics. The necessary skills could be practiced, times recorded, and accuracy proficiencies maintained for evaluation and review.

Some research has shown that the benefits from Infantry squad virtual exercises are primarily cognitive not greater individual skill proficiency (Pleban, Eakin, Salter & Matthews, 2001). Leader-focused training in virtual environments may improve leader decision-making skills without involving Soldiers. For the fire team leader, the young Sergeant transitioning from his duties as a member of the fire team to being the team leader or for the inexperienced platoon leader, the virtual environment provides an ideal setting for development of leadership and decision making skills as well as practical employment of some Soldier system skills. As indicated previously, leaders can use the inherent operational capabilities of ground Soldier systems to plan a mission. With a virtual training capability, the initial mission planning could be executed with the operational system, with no ET capabilities needed for this mission phase.

For ground Soldier systems, virtual collective training environments will most likely be part-task trainers. The challenge is to fully understand where this technology has the greatest potential to add value.

CONCLUSIONS

Given the current knowledge of and experience with ground Soldier systems, it is possible to systematically identify where embedded virtual simulation training is appropriate and beneficial for individual tasks. One ET mode is embedded exercises for initial skill and task training, with potential application to skill sustainment. Embedded exercises could be a very efficient training strategy and also provide challenging hands-on training.

The proposed ET rationale is a means for identifying individual tasks appropriate for ET. A similar rationale could be developed to identify collective tasks or aspects of collective tasks appropriate for embedded virtual simulation training. These two analyses could also determine whether ET provides part-task or whole-task training. Regardless, the final ET solutions must not adversely impact operational capabilities. The ET solution must work within the system's SWAP parameters, not expand them. Whether ET modules are fully embedded "go to war" solutions or appended solutions depend on such factors.

Lastly, potential ET virtual solutions should be pilot-tested. If Soldiers and leaders do not accept them nor perceive training benefits, this needs to be known early. This input will impact the final training solution and strategy.

REFERENCES

[1] Copeland, D. (2007). Stryker unit deploys with Land Warrior: Getting dismounted Soldiers in the future network. *Infantry, 96*(3), 18-22.

[2] Dyer, J. L. (2009) *Annotated bibliography of the Army Research Institute's training research supporting the Land Warrior and Ground Soldier Systems: 1998-2009*. (Research Product 2009-07). Arlington, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

[3] Finley, D. L., Alderman, I.N., Peckham, D. W. & Strasel, H. C. (1988). *Implementing Embedded Training (ET). Volume 1. Overview* (Research Product 88-12). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC ADA204401)

[4] Hall, G., Dyer, J., Wampler R., Blankenbeckler, N., Blomquist, R, & Cheves, R. (2005). *Embedded training technical memo for Future Force Warrior.* Unpublished manuscript by the FFW Embedded Training Working Group for General Dynamics C4 Systems.

[5] James, D. R., Dyer, J. L., & Wampler, R. L. (2008). *Exploring the potential value of OneSAF at the small-unit level* (Research Report 1884). Arlington, VA: US Army Research Institute for the Behavioral and Social Sciences. (DTIC ADA480202)

[6] Pleban, R. J., Eakin, D. E., Salter, M. S., & Matthews, M. D. (2001). *Training and assessment of decision-making skills in virtual environments* (Research Report No. 1767). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC ADA389677)

[7] Strasel, H. C., Dyer, F. N., Roth, J. T., Alderman, I, N., & Finley, D. L. (1988) *Implementing Embedded Training (ET). Volume 2. Embedded training as a system alternative (*Research Product 88-22). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC ADA204836)

[8] TRADOC. (2003). *Training: Objective force embedded training users' functional description* (TRADOC Pamphlet 350-37). Ft. Monroe, VA: Author. Retrieved from http://www.tradoc.army.mil/tpubs/pams/p350-37.htm.

[9] TRADOC. (2006). *Capability Development Document for Ground Soldier System, Version 1.1*. Ft. Monroe, VA: Author.

[10] TRADOC. (2007). *Systems approach to training, management, processes and products* (TRADOC Regulation 350-70). Ft. Monroe, VA: Author. Retrieved from http://www.tradoc.army.mil/tpubs/regs/r350-70.html

[11] TRADOC. (2009). *Capability Development Document for Ground Soldier System (GSS) Increment 1 Ground Soldier Ensemble (GSE).* Ft. Monroe, VA: Author.

[12] Witmer, B. G., & Knerr, B. R. (1996). *A guide for early embedded training decisions* (2nd ed.). (Research Product 96-06). Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences. (DTIC ADA315823)